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ABSTRACT

Students often hold personal explanations for natural phenomena that are intuitive, alternative to current scientific explanations, and extremely tenacious. This research effort attempted to document and interpret if and how exposure to conceptual change instructional techniques influenced one experienced teacher's conceptions of teaching science and to better understand how educators might encourage experienced teachers to modify their science teaching as they incorporate principles of conceptual change teaching into their instruction. The study was designed to follow a school teacher as she was exposed to principles of conceptual change and as she incorporated those principles into her instruction. The Conceptions of Teaching Science (CTS) Tasks Interview was used to analyze her thoughts about science teaching and learning at the onset of the project. Qualitative research techniques were used in data collection and analysis. Topics covered in the interview analysis include students' disinterest in science, public images of scientists and the sciences, questioning and student curiosity, inaccessibility of science instruction due to unintelligibility, concrete versus abstract dimensions, hands-on science, learning environment, student-centered instruction, and the dynamic nature of science. The report also outlines the next phase of the research project. The modified CTS instrument is included. (JRH)

IMPLEMENTING CONCEPTUAL CHANGE INSTRUCTION:

A CASE STUDY OF ONE TEACHER'S EXPERIENCE

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INTRODUCTION

Students often hold personal explanations for natural phenomena that are intuitive, alternative to current scientific explanations, and extremely tenacious. Since learning is an active process in which knowledge is constructed through the combination of new information with existing ideas, science educators are often faced with the challenge of motivating learners to alter their thinking when a scientifically accepted explanation is incompatible with their own notions. In traditional science teaching, scientific authority is believed to be enough to create dissatisfaction with a learner's personal conception. There are cases, however, where the learner may not accept the alternative concept and relinquish their existing belief. It is in these instances, teachers are prompted to go well beyond the passive transmission of content or facts and teach for the process of conceptual change if students are going to effectively learn science.

The desire to know more about practices associated with teaching for conceptual change is indicated by the growing focus on this topic in the science education community. Numerous studies are published in the science education literature and reported at professional conferences such as AERA, NARST, and NSTA. Substantial reviews of these studies have been compiled by Driver and Easley (1978); McDermott (1984); Driver, Guesne, and Tiberghien (1985); and Osborne and Freyberg (1985). In 1989, Volume 11 of The International Journal of Science Education was a Special Issue entirely devoted to research on students' conceptions.

In addition, instructional programs focused on changing students' conceptions such as the Children's Learning in Science Project at the University of Leeds, England (Scott, Dyson, & Gater, 1987) and the Project to Enhance Effective Learning at Monash University, Australia (Baird & Mitchell, 1986) have long histories of attempting to address student's scientific understandings through conceptual change instruction. Three international

seminars have been devoted exclusively to discussion of students' scientific conceptions and research on the learning of science concepts (Helm & Novak, 1983; Novak, 1987, 1993).

In the late 1980's an award-winning video, A Private Universe, depicted students at their college graduation articulating a variety of incorrect but common misconceptions of the reasons for changes in seasonal weather. A Private Universe symbolizes a crucial reality facing science educators. In spite of the high level of education represented by these graduates, science instruction had failed to overcome the persistent preconceptions held with respect to this natural phenomenon.

Science education research now faces the challenge of developing strategies that can assist educators in teaching for conceptual change. Stofflett's (1992, 1993) work has focused on acquainting novice teachers with the ideas of conceptual change and including pedagogical practice informed by research in conceptual change in teacher preparation programs. Results presented by Stofflett and Stoddart (1994) are encouraging and indicate the need for teachers to experience some aspects of conceptual change learning themselves prior to implementing lessons designed around principles of conceptual change. We suggest that different approaches may need to be taken in order to encourage experienced teachers, who have already established their own teaching styles, to incorporate the practice of teaching for conceptual change.

In the fall of 1994, the Science Media Group at the Harvard Smithsonian Center for Astrophysics held a series of nine satellite teleconferences as part of an effort known as The Private Universe Project. Live interactive broadcasts brought teachers and science education researchers together from locations in North America, Central America, and Europe for a conversation on constructivist learning and teaching for conceptual change. The creation of a six-part television series designed to inform and influence science teachers, school administrators, parents, and policy makers is the eventual goal of this federally funded project. Discussions during the teleconference indicated an affinity for the ideas of

conceptual change and constructivist learning. However, it was clear that implementation of these ideas into the practices of teachers will not be easy since dramatic changes in traditional pedagogy are required and acceptance of conceptual change instruction by those outside the science classroom requires an informed citizenry.

If academic or research interest in teaching for conceptual change is going to have an impact on science teaching, it is clear that the ideas must first be accepted and adopted by those people already established in the profession, such as science teachers, science supervisors, science educators, and administrators. Besides informing teachers of the principles of conceptual change instruction, the academic community must develop realistic methods for assisting with and encouraging modification of existing practices. Since the elementary classroom is likely to be the first place most students receive exposure to formal science concepts, this should also be considered an important site for conceptual change research. The goal of this research effort is to document and interpret if and how exposure to conceptual change instructional techniques influenced one experienced teacher's conceptions of teaching science.

METHODOLOGY

Our aspiration is to better understand how educators might encourage experienced teachers to modify their science teaching as they incorporate principles of conceptual change teaching into their instruction. This study is designed to follow a school teacher as she is exposed to principles of conceptual change and as she incorporates those principles into her instruction. While it would certainly be possible to study numerous teachers in a broader context, we feel a richer description and more detailed analysis can be gained from closer interaction with a single person. This methodological technique produces results that, in connection with other research on conceptual change instruction, can inform both the research community and science educators.

As Stake (1994) suggests, the case study is not always a methodological choice, but often the choice to study the particular case. We are fortunate to have found a teacher particularly well-suited to the collaborative nature of this project. The teacher selected for participation is an experienced professional who has taught in excess of ten years at several different elementary schools. She agreed to participate in this project by allowing a science education researcher at a midwestern university to observe and participate in the instruction of science lessons in her classroom. She is in the process of completing a Masters of Arts degree in Elementary Education and has indicated a willingness to try alternative approaches to science teaching. Her class is a fourth and fifth multi-grade classroom with twenty-three pupils in a suburban school district.

This research is designed with the co-authors having distinct and separate functions. One of the authors (LSJ) will interpret the teacher's concepts of teaching science throughout the study. The other author (MEB) is responsible for introducing the practice of teaching for conceptual change to this teacher. At this time, we have established an understanding of her conceptions of teaching science, but have not begun to introduce her to the concepts of teaching for conceptual change. As the project is longitudinal in nature, this will require a series of interviews conducted at appropriate stages in the project. By separating the functions of the researchers, with one introducing the concepts and the other discussing the impressions they make on the teacher, we hope have a better chance of determining how she actually responds, rather than how she might think we want her to react to the process.

In order to identify and analyze her thoughts about science teaching and learning at the onset of the project, we used the Conceptions of Teaching Science (CTS) Tasks Interview (Hewson & Hewson, 1988). This instrument is based on the Interview About Instances devised by Osborne and Gilbert (1980). The format is an open-ended, indirect interview where the subject is prompted to discuss a series of selected scenarios. Elementary teaching

is more child-centered and less subject-focused and elementary teachers may be reticent to discuss science teaching. We considered the CTS format particularly suited to encouraging reflection by an elementary teacher since it does not initially ask specific questions about science content and the interviewer can probe responses in a number of different directions once the conversation is in progress.

In this case, the scenarios were modified to be age-appropriate by describing events involving younger children to provide relevance to the elementary school context (see Table 1). Each scenario involved a situation chosen to prompt the interviewee to consider if science teaching or learning was occurring in a given scenario. She was asked to give her impressions of whether science teaching or learning were going on and her initial response was followed with queries by the researcher to encourage elaboration. Discussion was often directed toward topics of interest such as the a priori categories (see headings in Table 2) used in the initial data analysis. This was done with the understanding that an interview is, in actuality, "a conversation with a purpose" (Kahn & Cannell, 1957, p. 149).

Since our goal was to document her Conceptions of Teaching Science in this initial phase of the research project, we modified the categories for analysis suggested by Hewson and Hewson (1988). Due to the large amount of overlap, we collapsed "Learners and Learning" into a single cluster. We also used "Nature of Science," "Rationale for Instruction," and "Preferred Instructional Technique" to sort the information contained in the text of the interview.

Table 2 contains a condensation of the categorized and sorted data. In this research the teacher's narrative serves as an analog to the graphical representation of data in empirical research (Huberman & Miles, 1994). The statements come from the initial recorded interview which was transcribed verbatim with each line of this transcript numbered sequentially. After manually bracketing statements that related to the analysis categories, a code was placed in the adjacent margin to facilitate sorting the data. Two

independent passes were made through the transcript by the interviewer (LSJ) and compared to similar exercises conducted by the other researcher and an uninvolved colleague. Each statement applying to an analysis category was moved to a separate list and the line identification remained in the left margin. Each of the four major categories was then sorted into topics that further organized the responses before the written analysis of the interview was made. This sorting took place because other themes emerged during the data analysis that are particularly relevant to the goals of this project.

Five months after the original interview, a second interview using the same format, but different scenarios, was conducted to confirm the researcher's impressions of the teacher's ideas. In addition, a deliberate member check was carried out with the teacher to ensure that she felt our interpretation reflected her Conceptions of Teaching Science. After giving a written analysis to the teacher for critique, this member check was documented by a tape-recorded conversation. Other than asking for clarification of a point that has been deleted from the subsequent analysis, she indicated the document was an accurate reflection of her views (She also reviewed and approved this manuscript.).

The interpretive analysis that follows is based on these three conversations with this teacher. It does not follow the standard CTS organization because our purpose is not to make comparisons to other CTS interviews. Instead it represents what Glaser (1978) would consider a theoretically sensitive outcome of the inductive process. At this stage of this research process, the analysis could be considered a baseline assessment of her conceptions of teaching science from the perspective of the researcher. While these are the impressions of another person, her own words are included often to support general claims. Any comments enclosed by quotation marks are the words of the teacher.

The ideological framework for our work comes out of an interpretivist research perspective endeavoring to construct meaning through induction. Theory is generated on the basis of observations, made in this case through the interview process. The ontological

premise of interpretivism lies in the nature of reality being its multiplicity. Our study will only involve a single teacher and no claims will be made for generalizability to all teachers. The epistemological challenge will be to generate knowledge that is valuable through the understanding we develop from the rational and intuitive interpretations of this individual's statements.

INTERVIEW ANALYSIS

This particular elementary school teacher was very willing to discuss her ideas about science teaching in all of our conversations. I nave the impression that science lessons are considered an important aspect of the education of her students. Aware of the universality of the sciences, she states that "it [science] is basically going on all around us in every day life." The understanding that "science is not something confined to the class or a lab" seemed to be a reason she feels it is crucial to offer quality science instruction to her students.

She explained her feeling that disinterest in science may arise from situations when science is not always made relevant to the daily lives of people. Science vocabulary is a particular problem and can be literally overwhelming. "What we ought to do is not like kill it [science] for children, beat it with a stick until by the time they hit middle school, they hate science or they don't like it or they think it's beyond their scope." She said science instruction should center on "what the students want to know," with their lessons based on "what they are interested in." She further stated that she tries to focus on topics "related to their daily life" and has an idea of what she thinks they need to learn.

In discussing why students dislike science, she talked about a difficulty "connecting with it." Some teachers' inability to "nourish inquiry" is seen as damaging. She structures her teaching to do "whatever it takes to help them gain from instruction," realizing that it is important to "express things in different ways" so that there is a greater possibility of more

students grasping the message. Believing that "both boys and girls can be good at science," this instructor encourages them to "be themselves and grow into what they want."

Many references were made to the public images of scientists and the sciences. Science "does not always have all the answers" and loses credibility with the public when ideas change dramatically. She remarked that great scientists "often work by teaching themselves" and become somewhat detached, ending up isolated in their laboratories. Scientists were described as people who "have strong interests or gifts in a particular area" and she wondered whether "they were bom with the motivation or it was encouraged." Their focus seems to have led them "to excel in it, gain knowledge, and end up highly educated."

Questioning, both as a natural manifestation of student curiosity and a central aspect of scientific activity, was mentioned often. This teacher inferred that the task of turning learner curiosity into scientific inquiry is a very natural way to encourage her pupils to do science. Her own preference for learning science in this manner served as the incentive to teach her students to do so. "[I]t's becoming clearer to me that when I was interested in science, especially as a young person, I always wondered and would ask a lot of questions. Even when things were taught to me directly, I wanted to know why and so I think now it has come full circle and I want to encourage children to ask questions and to wonder and to look themselves at what they're wondering about..." She talked about giving her students "lots of room to ask questions" and pursue "their own paths of inquiry" to seek information such as science concepts or content. She described starting "with blank faces," then seeing "their interest stimulating comments and questions," and eventually seeing them "pursue" things and "come up with their own answers" in some cases.

Awareness of the fact that students are easily discouraged by science instruction when it is inaccessible due to unintelligibility, seemed to motivate her to be very concerned with the importance of making scientific knowledge age-appropriate for the students. When the subject matter is "developmentally over their heads," learning science becomes

distressing and students "think it is beyond their scope." The need to understand the fundamentals of child development and present appropriate conceptual topics with content that is concrete rather than abstract was mentioned often. She talked specifically about teaching concepts that are developmentally suitable so that students can "make link ups." Teachers should have a "clear understanding of child development" in order to understand "what they can relate to."

In her classroom, she teaches more in the concrete dimension, but has seen her students "make leaps to ideas that are abstract." This enables her pupils to make conceptual leaps on their own and makes science something they are more likely to relate to. Often stressing the importance of concrete issues that they can visualize, even adults learn best when science begins with "concrete or representational" examples, but it is extremely important to understand this is true for children. Since this is the way she has always "learned best," the assumption seems to be that others learn best this way, too.

Having gone through a radical change in the way she teaches science, this teacher is very conscious of her own style. She used "to assign chapters to read and answer questions at the end," teaching so that it was "easy to manage her class," but now she uses more inquiry-based instruction. Determined "not to kill" the interest that the students naturally have, her goal is to "give them the richest environment possible," making every day a "new and fun experience." She now sees that "it makes sense to teach in an informal way," having gained the confidence to teach the way she wants, rather than the way that traditionally seems to be expected. Students are provided with opportunities to do more hands on science by giving background and resources and letting them do projects that "incorporate math and reading while strengthening their science." She gives them time "to fiddle around and kind of go off in their own direction on their own paths of inquiry." Pupils are allowed to plan their own scenarios, test what they have found, write up their results and present

them to the class. Good science teaching allows children to pursue "what they are interested in and lets them go their own way."

The way this woman now teaches science involves setting up an environment where children can "absorb and grow and learn." She wants children to question and "leaves plenty of room" in her classes for them to do so. A goal is to help them gain information by directing, rather than habitually imparting the information "by doing lessons in front of them." She likes to see them generate inquiry questions where they are involved. Her function is to set up an experience where it is possible to learn, to ask questions, to wonder, or to pursue and come up with their own answers. In describing her teaching, she said, "it's not me always directly imparting information. It's setting up an environment where the children can absorb, and grow, and learn."

The interviewee is very conscious of what she does in her classroom and has reflected her reasons for doing so. She made very easy connections between the scenarios presented and her own classroom practice. The whole point of teaching science is to make things clear to her students. There is a great deal of focus on teaching in ways that "help them to gain information." While science learning can take place in isolation, her preference is for a high level of interaction. The belief that youngsters can "impart information" to each other and benefit from "peer teaching" lead her to support the idea of collaborative learning. She likes to see them share with each other through conversations and discussions or working toward "some kind of group presentation." She has seen the payoff for her teaching come in positive feedback from parents. They love the way she teaches "because their kids are real interested." In talking to parents she notices that "if they have a sense that she knows their children, they trust her and what she is telling them."

The interviewer (LSJ) has a strong impression that this teacher has an affinity for science since many of the comments on her methods of teaching had very strong personal connections. She mentions always "loving science" because she wanted to understand the

reasons for things, but says she "never dreamed of being a scientist. She seems to feel that the essence of science lies in an excitement that is linked to the enormity of such an "unlimited process" and refers to "the importance of imagination." Science is not seen as a static process. She is aware of the dynamics and mentions "how wonderful it is that ideas change all the time." There was mention of the ongoing "dialog" and "the idea of constantly rethinking and extending in the system." This translates to the understanding that the instructor does not have a responsibility "to know everything in her classroom."

She convinced the interviewer in our conversations that she has thought a great deal about her own learning process, things that facilitated learning for her and carries these into her ideas about teaching her own students. She thinks they need to be given lots of "opportunities to go in their own direction," leading themselves "by fiddling around." One comment she made that seemed to summarize her pedagogical style for science instruction, "I try to make it [science] friendly, user-friendly."

DISCUSSION

As science educators, the interpretive analysis of interest is the "realist tale." The choice has been made to present this case study with the purpose, goals, and audience of this project in mind. It is not the only narrative form that could have been used with this text and in order to avoid the common tone of "authoritative omnipotence" (Van Maanen, 1988) it is appropriate to engage in some reflexivity.

The preceding interpretation of the teacher's comments is heavily influenced by our training as educational researchers. We organized her comments according to categories deemed to be crucial components of an individual's conceptions of teaching science. Our own experiences as teachers provide a certain empathy on issues such as class management, student interest, and parental feedback. Something of an outsider's perspective, with heightened interest in comments on child development, came from the fact that the interviewer has not taught at the elementary level. In contrast, my background and

experiences as a research scientist interested in science education (LSJ) made me very impressed with the accurate perception and keen insight she had with respect to the nature of science and its process.

This experienced teacher has a well-established concept of teaching science, extensively documented in the previous two sections of this paper. In these conversations, there was no specific mention of teaching for conceptual change, so we suspect the theoretical model will be new information to her. Thus, if she accepts the ideas, it will come through a process of conceptual change in which these different ideas are incorporated into her existing framework.

According to Posner, Strike, Hewson, & Gertzog (1982), four conditions must be fulfilled in order for such accommodation to occur. New conceptions must be intelligible, plausible, fruitful, and occur in conjunction with dissatisfaction with existing concepts. This baseline assessment indicates the potential for this to happen. She has expressed dissatisfaction with existing conceptions of teaching and said, "...I've really backed away from even as a teacher, my definition of what teaching is. It's not me always directly imparting information." She indicates the ideas of conceptual change instruction will be intelligible by saying that [there are times in science classes when] "maybe a few people are going to grasp it and if you repeat it several times, maybe some people are going to memorize it, but there's going to be a lot of people who don't understand and need other ways to learn..." It would seem that she would find teaching for conceptual change plausible, because she discussed "evaluating and assessing what kids already know, where they're at and then you'll be better able to key in on what kids want to know and where to go from there." Her desire to make an effort to teach in ways that benefit her students, reflected when she said "I try to make link-ups, I guess to their lives and what makes sense to them, but it's in their terms," suggests she would find conceptual change teaching fruitful.

During the next phase of the research, this teacher will be encouraged to implement the principles of conceptual change instruction. The two major components of the Conceptual Change Model (CCM) of Posner et al. (1982), namely status and the conceptual ecology, will be the focus of future efforts between the teacher and the researchers. The teacher will be instructed in the status component of the CCM. She will be asked to read literature describing status and studies done to elicit the status of learner's conceptions. She will audio-record interviews with individuals and groups of students prior to, during, and following instruction to determine which conceptions her students hold and the status of a conception to a particular student. The researcher (MEB) will assist the teacher in the analysis of student interviews for status related interactions. Thorley (1990) defines these as statements that can be identified and categorized as indicating the intelligibility, plausibility, or fruitfulness of a conception. Analysis of statements contained in these interviews can provide an indication of the student's current conceptual understanding and inform the teacher's planning and delivery of future instruction.

The teacher will also read and discuss with the researchers, articles describing the conceptual ecology component of the CCM. She will be asked to take special note of the student's abilities to actually use or refer to one or more of the components of the conceptual ecology during recorded interviews and classroom instruction. Instances in which aspects of the conceptual ecology either facilitated or inhibited student understanding will be documented by the teacher. Inferences about the impact of these criteria on student's learning will be suggested by the teacher and the researcher. As with the status component, information related to the conceptual ecology provided by the student may influence future instruction presented by the teacher.

Throughout the continuation of this study, the teacher's Conceptions of Teaching Science will be monitored as she introduces principles of conceptual change into her instruction. Changes from the baseline information on her views presented in this paper,

will be noted. It is recognized that this research uses three status terms and the conceptual ecology components of the CCM as categories of analysis for student understanding of science content. Additional categories useful in the analysis of student conceptions may emerge as the study progresses. Although not an intentional part of the design of this study, it is recognized that a study of this nature can and should provide clarification concerning the existence or utility of status and components of the conceptual ecology to the CCM itself. Completion of this study may give insight, not only into the process of encouraging experienced teachers to adopt the practice of teaching for conceptual change, but also into further development of the theoretical components of the CCM.

LITERATURE CITED

Baird, J. R. & Mitchell, I. J. (1986). Improving the quality of teaching and learning: An Australian case study - The PEEL Project. Melbourne, Australia: Monash University Printery.

Driver, R., & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. Studies in Science Education, 5, 61-84.

Driver, R., Guesne, E. & Tiberghien, A. (1985). Children's ideas in science. Milton Keynes, U.K: Open University Press.

Glaser, B. G. (1978). Theoretical sensitivity. Mill Valley, CA: Sociology Press.

Helm, H. & Novak, J. D. (1983, June). Proceedings of the international seminar-misconceptions in science and mathematics. Ithaca, NY: Cornell University Press.

Hewson, P. W. & Hewson, M. G. A'B. (1988, April). Analysis and use of a task for identifying conceptions of teaching science. Paper presenter at the Annual Meeting of the American Educational Research Association. New Orleans, LA.

Huberman, A. M. & Miles, M. B. (1994). Data management and analysis methods. In N.K. Denzin & Y.S. Lincoln (Eds.) Handbook of Qualitative Research. Thousand Oaks, CA: Sage.

Kahn, R. & Cannell, C. (1957). The Dynamics of Interviewing. New York: John Wiley.

McDermott, L. (1984). Research on conceptual understanding in mechanics. Physics Today, 3-10.

Novak, J. D. (1987, July). Proceedings of the second international seminar-misconceptions and educational strategies in science and mathematics, Vol. I-III. Ithaca, NY: Cornell University Press.

Novak, J. D. (1993). Proceedings of the third international seminar-misconceptions and educational strategies in science and mathematics. Ithaca, NY: Cornell University Press.

Osborne, R. J. & Freyberg, P. (1985). Learning in science. Auckland, New Zealand: Heinemann.

Osborne, R. L & Gilbert, J. K. (1980). A technique for exploring students' view of the world. Physics Education, 15 (6), 376-379.

Posner, G. J., Strike, K. A., Hewson, P. W. & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66 (2), 211-227.

Scott, P. H., Dyson, T, & Gater, S. (1987). A constructivist view of learning and teaching science. Childrens' Learning in Science Project, UK: Leeds.

Stake, R. E. (1994). Case Studies. In N.K. Denzin & Y.S. Lincoln (Eds.) Handbook of Qualitative Research. Thousand Oaks, CA: Sage.

Stofflett, R. T. (1992). Is the ability to use conceptual change pedagogy a function of personal experience? Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.

Stofflett, R. T. (1993). Accommodating pedagogical conceptions in an elementary science methods course. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Stofflett, R. T. & Stoddart, T. (1994). The ability to understand and use Conceptual Change pedagogy as a function of prior learning experience. Journal of Research in Science Teaching, 31 (1), 31-51.

Thorley, N. R. (1990). The role of the conceptual change model in the interpretation of classroom interactions. Unpublished doctoral thesis, University of Wisconsin-Madison.

Van Maanen, J. (1988). Tales of the Field: On Writing Ethnography. Chicago: University of Chicago Press.

Table 1 - Modified CTS Instrument

Conceptions of Teaching Science Interview
Examples of Instances of Science Teaching and Learning

Protocol:

1. In your opinion is science teaching or learning going on in each of the following scenarios? What is the reason for your answer?
2. If you are not sure, what additional information would you need to know? How would this information clarify this?

Items:

1. <u>Teacher handing out objects</u>
A sixth grade teacher passes out the skulls of ten different animals and asks the class to compare the teeth.

2. <u>Children watching TV</u>
Three siblings in the second, fourth, and sixth grades are at home watching a NOVA program on "The Wonders of the Universe".

3. <u>Students in the library</u>
Two older students work together on an assignment to predict their height in 5 years from graphs depicting growth rates.

4. <u>College Professor and students</u>
While visiting a second grade class, a college professor gives a presentation on their work on DNA.

5. <u>Teacher lecturing class</u>
A fourth grade teacher stands in the front of the class and explains the physical states of matter to the students.

6. <u>Teacher questioning Individual</u>
In a one-on-one conference, a student is asked to clarify a statement made in their science journal that "sunlight makes plants grow".

7. <u>Teacher asks student to label drawing</u>
After a unit on plants, the teacher asks third grade students to label the parts of a flower from memory.

8. <u>Student asks a question</u>
A first grader watching a teacher fill a helium balloon for a party asks why it rises and the ones they blew up with air sit on the table.

9. <u>Student working alone</u>
A fifth grade student works at home alone assembling a motor-driven model boat from a kit received as a gift.

10. <u>Teacher writing a self-study program</u>
A teacher from Cape Cod with a special interest in bogs writes a self-study program for other teachers to use before a school field trip to Buckeye Lake.

Table 2 - Display of Selected Data from the Transcript

LEARNERS

Questioning

28 I always wondered and would ask a lot of questions
30 I wanted to know why
44 they're seeking out certain kinds of information
137 [need] lots of room to ask questions
180 kids begin to question or make comments
336 to ask questions or to wonder or to pursue it or to come up with their own answers

Development

48 developmentally maybe over their head
54 where they're at in a concrete way
6[illegible] developmentally what they can relate

Affinity

193 hate science or they don't like it
197 we all should love it and be curious
217 they like the vocabulary if they feel like they can take ownership
220 they don't feel connected to it
381 kids surprise me by how interested they are, how excited they are, how much they want to know
283 sometimes they want to know things I am not particularly interested in, but to them it's really interesting

Process

79 need to be given lots of different opportunities
137 time for kids just to fiddle around
138 go off into their own direction
341 it was something they observed

Understanding

119 people who don't understand and need different ways to learn
127 the way I learn best and I assume that is the way most people learn
281 when I am forced to explain something or to write something it helps me clarify in my own mind like what it is I've learned or what I'm doing
528 I'd have to really research and clarify and be able to not only maybe understand it but to be able to explain it

RATIONALE FOR INSTRUCTION

Students Themselves

67 sometimes people don't always understand that everyone doesn't get it
77 have the expertise of understanding that people have different ways of learning and need to be given lots of opportunities
213 express it to them in lots of different ways
399 being themselves and being able to grow in what they want
421 doing what they are interested in
458 better for kids to do inquiry
494 What [topics] I have seen kids responding to

Knowing Students

57 a special understanding of children developmentally
63 clear understanding of young children and developmentally what they can relate to
151 getting to know my kids is basic

Personal Feelings

198 ideas change all the time and that is wonderful
211 we take it out of their hands
228 I didn't dream of being a scientist, but I just wanted to know why
241 I encourage my students to question
299 I'd want to know why and what is the point of it
366 I don't have the responsibility to know everything
511 I like the idea of constantly changing and rethinking and extending.

Parents

169 if I talk to parents if they have a sense that I know their kids they trust me and trust what I am telling them
460 feedback has been positive from the parents
46[illegible] parents love it because their kids are real interested

Teaching

145 if you start with good ground work, then you don't have all the confusion or the misinformation
191 what we ought to do is not kill it for the kids
369 give them the richest environment that I can at any time
385 it's fun that way. it's like every day is a new experience
417 I used to teach so it was easy to manage my class
424 feel it was Ok to let go of the old ways
455 have the confidence to teach the way I thought was good
473 made sense to teach in an informal way
481 I hear all the reasons people give for not teaching the way we teach but I don' find them to be true when I do.

PREFERRED INSTRUCTIONAL TECHNIQUE

Concepts

5 evaluating and assessing what kids already know
19 it depends on your definition of teaching
135 you have to tie it to something. you have to anchor it to something.
177 I don't design lessons that [traditional] way
183 pull in another area that relates to their life
184 try to bring things back to their backyard if I can
187 try to make link-ups to their lives and what makes sense to them but it's in their terms
195 I really try to make it friendly, user-friendly
237 nourish that inquiry that it is okay rather than squashing it
276 part of teaching is extending [what the students know]
368 I just need to understand kids and give them the richest environment that I can at any time.
469 it made sense to me to teach in an informal based way

Table 2 - continued...

Development

53 with that kind of expertise to be able to relate to small children

55 make analogies using very concrete objects

58 really have to understand where children are

71 they would keep repeating the same things and say to you I don't understand why you don't get this and then they would keep showing you the same thing over and over again and they didn't understand why you didn't grasp what they were teaching you.

123 I firmly believe even as an adult everything needs to be taught in a concrete way first

127 the way I learn best and I assume that is the way most people learn

131 deal first with the concrete and representational kinds of things

Asking Questions

31 I want to encourage children to ask questions

137 lots of questioning. lots of room to ask questions.

?09 I'd ask questions

?11 generating kinds of inquiry questions where they would be more involved

335 by setting up the experience for them to learn, to ask questions, to wonder, or to pursue it or to come up with their own answers

Interactive

42 getting into more peer teaching

42 kids imparting information maybe together

153 work towards some kind of a group presentation or something

157 lots of conversations

166 nothing to me beats like knowing my kids

178 having a discussion

182 share something on the board

Teacher Actions

22 it is not me always imparting information.

23 it is setting up an environment where the children can absorb and grow and learn

33 trying to help them get more information or direct them

152 having lots of room to like talk to them

177 I don't tend to do lessons in front of kids

241 I think that [questioning] should be encouraged and so I encourage my students to

377 you get across to them that they are perfectly capable and you are interested in what they are interested in

387 reinforcement is a very deliberate part of teaching

396 recognize them and you nurture them

406 help them get further in that direction that it just energizes them

411 when I started teaching I did some really stupid things like assign chapters to read and answer questions at the end because it was easy to manage

420 more in hands on science

429 just background knowledge and resources and ideas of helping kids with projects

441 have projects to do the kinds of things they incorporate like math and reading and all that strengthen their science

470 talk about what I think and what I know

Student Activities

112 they're giving you a formula

138 lots of time for kids to just fiddle around and kind of go off in their own direction. their own paths of inquiry.

320 test what they found out and demonstrate it to the class

358 you can teach yourself science in isolation

421 children doing what they were interested in

458 better for kids to do inquiry and work on their own

NATURE OF SCIENCE

Universality

196 like it's all around us

196 we all use it

348 science is all around us

349 science is in every day life

351 basically science is going on [in almost anything we do]

Essence

216 it's not related to their daily life

217 vocabulary is sometimes overwhelming

233 they used to say something else 20 years ago, so why has it changed

263 imagination is in science too

487 the way I teach is truer to the real essence of science

501 the essence is an excitement

503 it's just unlimited

509 to me it's like dialog

511 the idea of constantly changing and rethinking and extending

Scientists

91 they get where they are because they first excelled in that area

92 have a strong interest in that area

93 a strong gift in that area

93 they become more and more focussed at a higher level of understanding

95 they become somewhat detached

194 it's for those few people that like it that are weird

198 [they]don't have all the answers

360 that's how to me the great scientists work any way [by teaching themselves]